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**Engaging caregivers in making: The role of physical and social settings in museum-based
making and tinkering activities**

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Abstract

Many studies have documented the impact of maker experiences on children's learning, but few have examined how caregivers participate in maker activities in museums, both as facilitators of their children's learning and as learners in their own right. This qualitative study involved observations and interviews with 88 caregivers participating in a range of making and tinkering activities at a science museum. Aspects of the physical setting (including the arrangement and familiarity of tools and materials) and social setting (including facilitators' interactions with children versus caregivers) influenced whether families participated and the roles that caregivers played (observing, facilitating, or making). Across these roles, caregivers described benefitting as learners — by noticing their children's abilities and interests, learning new ways to support their children's learning, or fostering their own creativity. The results highlight strategies that museums can use to create inclusive maker activities that recognize caregivers' many roles and motivations during family visits.

Engaging caregivers in making: The role of physical and social settings in museum-based making and tinkering activities

A long line of research has documented the benefits of making and tinkering as pathways for informal STEM learning (see Vossoughi & Bevan, 2014 for a review). Although many studies have focused on adolescent and adult learners, a smaller number of studies have demonstrated the promise of family-focused maker experiences for supporting children and adults in learning together (Brahms, 2016; Brahms & Werner, 2013; Roque, 2016).

Recognizing this potential, many science centers and children's museums have begun offering making and tinkering activities to family audiences. Since 2013, the "Making and Tinkering Spaces in Museums" community of practice, hosted by the Association of Science and Technology Centers, has grown to include hundreds of members, with active discussions about how to organize and facilitate maker experiences for families. In many museums, these experiences are relatively self-directed; hands-on materials and tools are available for children and their families to explore on a drop-in basis with support from facilitators. Free-choice maker activities that exist alongside other museum exhibits are increasingly common and potentially attract museum visitors with little prior interest or experience with making. Engaging caregivers in these contexts may be especially critical, as caregivers are gatekeepers for many informal learning opportunities in children's lives.

The current study extended existing research on family learning in museums and maker spaces in two key ways: First, we focused on caregivers as a distinct learning audience, given that previous studies of family learning in maker spaces have primarily focused on children's learning. Second, we examined how the design and facilitation of maker programs jointly

contributed to caregivers' involvement, extending prior work that has examined physical and social factors separately.

In asking these questions, we also acknowledged the implicit tension in museums' desire to increase caregivers' engagement: on the one hand, caregiver involvement can support and guide children's learning (Weisberg, Hirsh-Pasek, Golinkoff, Kittredge, & Klahr, 2016), while on the other hand, it can limit children's curiosity, exploration, and autonomy (Bonawitz et al., 2011). As educational spaces rooted in constructivist and sociocultural approaches to learning, museums and maker spaces may operate on the (stated or unstated) assumption that active involvement on the part of caregivers is beneficial or even necessary, in effect prioritizing Western-European styles of caregiver-child interaction (Gaskins, 2008). In reality, caregiver-child interactions in informal spaces vary along many dimensions and for many reasons, and caregivers' needs and goals for their visits may not align with museums' objectives (Downey, Krantz, & Skidmore, 2010; Gaskins, 2008; Letourneau, Meisner, Neuwirth, & Sobel, 2017; Wood & Wolf, 2010). This work suggests that in inclusive spaces that are inviting and welcoming to families, "caregiver engagement" will include a range of behaviors — from relaxation and observation to collaboration and direct instruction, depending on the motivations and needs of caregivers and their children. Some museums are responding to these concerns by articulating practices for supporting the wide range of roles that caregivers play in children's learning, as well as caregivers' own needs as museum visitors (for example, Chicago Children's Museum's "Role of the Adult" position paper, 2019; Boston Children's Museum's "Learning Together" staff training, 2012).

Similarly, efforts within the maker movement to create more equitable and inclusive environments for learning through making have highlighted the need for ongoing inquiry into the

assumptions and pedagogical practices that can invite learners in (or alienate them) and support learners' engagement in making (or discourage it) (Vossoughi, Hooper, & Escude, 2016). This work argues that the maker movement can marginalize forms of making practiced across cultures, overemphasize individual effort and learning from failure, and utilize sharing economy models of participation and time/resource sharing, all of which perpetuate educational injustices faced by learners from non-dominant communities (Schor, Fitzmaurice, Carfagna, Attwood-Charles, & Poteat, 2016; Vossoughi, Escudé, Kong, & Hooper, 2013; Vossoughi et al., 2016). This can result in a deficit view that focuses on increasing engagement with existing maker experiences, rather than redesigning experiences to become more equitable and inclusive. Although this critique extends well beyond the inclusion of adults within family groups, it reframes the issue: How can making and tinkering activities be designed not only to invite family groups but also to support the variety of ways that caregivers might choose to engage with them?

In this study, we posed the following research questions: 1) How do physical and social factors support or impede caregivers' participation in making and tinkering activities during family visits to museums?, and 2) How do caregivers describe the benefits of these activities, for their children and themselves?

Theoretical approach

Our approach brings together research on informal learning in museums, which describes learning as a sociocultural process (Crowley & Jacobs, 2002; Falk & Dierking, 2000; Zimmerman, Reeve, & Bell, 2010), and research in community psychology, which argues that physical and social settings jointly influence behavior on an individual, family, and community level (Gomez & Yoshikawa, 2017; Seidman & Capella, 2017). Both fields take an ecological or

systems perspective, emphasizing the dynamic interplay between the physical qualities of the environment, social interactions between people, and evolution of behavior (including learning) over time. In addition, we draw on research on the physical and social affordances of informal learning environments, which has identified numerous design principles that can support learners' engagement in free-choice settings (Allen, 2004; Borun, Chambers, Dritsas, & Johnson, 1997; Dancstep & Sindorf, 2018; Falk & Storksdieck, 2005; Humphrey & Gutwill, 2005).

Caregivers' engagement during museum visits. In informal learning environments, families function as interconnected systems — caregivers' engagement can influence how children are engaged, and vice versa (Gomez & Yoshigawa, 2017; Rogoff et al., 2016). Family learning in museums is inherently social, with families linking their new experiences with family memories, histories, and interests (Falk, et al. 1998; Ellenbogen, Luke, & Dierking, 2004; Zimmerman, Reeve, & Bell, 2009). Research in museum settings has shown that caregivers actively support children's learning in many ways — for example, helping children make sense of the phenomena they encounter (Crowley et al., 2001; Puchner, Rapoport, & Gaskins, 2001), and encouraging their emerging interests (Crowley & Jacobs, 2002; Falk & Dierking, 2000). However, caregivers' level of involvement depends on many factors, including family dynamics, cultural backgrounds, and personal interests (Gaskins, 2008; Puchner et al., 2001; Wood & Wolf, 2010). Informal learning is also culturally situated and builds on families' skills, habits of mind, and ways of knowing, shaping how families navigate shared learning experiences (Gutierrez & Rogoff, 2003; Bang & Medin, 2010). Finally, although caregivers' motivations for visiting museums are often centered on their children, caregivers may prioritize independence, togetherness, content knowledge, or relaxation/play, shaping the aspects of learning that they notice and value in these settings (Downey et al., 2010; Letourneau et al., 2017; Swartz &

Crowley, 2004). The roles that caregivers play during museum visits therefore vary widely (Beaumont, 2010; Gaskins, 2008; Swartz & Crowley, 2004).

In this study, we anticipated that caregivers would be involved in making and tinkering activities in multiple ways, and we aimed to understand how the design and facilitation of activities could support a range of roles for caregivers, rather than prioritizing one type of caregiver engagement. Previous studies suggest that museums often encourage caregivers to be active participants in children's learning, rather than observers, but that this is sometimes at odds with caregivers' own beliefs and desires for their museum visits (Gaskins, 2008; Wood & Wolf, 2010). This discrepancy in expectations can cause caregivers to feel unsure about how to be involved (Downey et al., 2010; Wood & Wolf, 2010), or to reject the assistance of facilitators (Pattison et al., 2012). Therefore, we focused on what caregivers said they gained from their experiences, and what aspects of the activities supported caregivers themselves as learners.

Making as a social activity. The social settings within maker spaces convey particular values and social norms that can influence how family visitors participate and the ways that they learn together (Falk & Dierking, 2000; Seidman & Capella, 2017; Vossoughi et al., 2013). For example, learners in maker spaces often share resources with one another and shift fluidly between the roles of novice and expert (Gutiérrez, Schwartz, DiGiacomo, & Vossoughi, 2014; Sheridan, et al. 2014). Maker spaces are also typically facilitated, and facilitators often self-identify as "Makers" (Brahms & Crowley, 2014; Martin & Dixon, 2013), using their own experiences as learners in this community to help them support visitors (Blikstein, 2013; Petrich et al., 2013). By offering accessible introductions to new tools, vocabulary, and ideas, facilitators can invite visitors into the community of practice (Vossoughi, et al. 2013) and sustain their engagement over time (Bevan, Gutwill, Petrich, & Wilkinson, 2015; Gutwill, Hido, & Sindorf,

2015). On the other hand, positioning “makers” as gatekeepers of specialized information can marginalize other forms and purposes of making that exist historically and across cultures (Svarovsky, Bequette, & Causey, 2016; Vossoughi et al., 2016).

Some studies have investigated how families learn together in the social context of community- and museum-based maker spaces. For example, Brahms and colleagues described how caregivers and facilitators in a museum-based maker space jointly scaffolded children’s learning over time (Brahms, 2014; Brahms & Crowley, 2016). This work illustrated the ways that caregivers drew on their own prior experiences to support children’s learning, but it also emphasized that caregivers’ expectations and assumptions sometimes hindered children’s creative process, necessitating design choices and facilitation strategies to guide caregivers’ participation (Brahms & Werner, 2013). In a library-based program focused on computational tools, Roque and colleagues found that it was important for caregivers to have opportunities both to learn independently and to collaborate with their children, and that together, these experiences helped family members to see each other in a new light (Roque, 2016; Roque, Lin, & Liuzzi, 2016). These studies have suggested a variety of strategies for supporting families in maker programs. However, there is a need for further research about the social aspects of maker experiences that can welcome and support caregivers as learners.

Physical design of making and tinkering experiences. Physical settings interact with social settings and surrounding institutional conditions to influence people’s behavior (Hawe, Shiell, & Riley, 2009; Seidman & Capella, 2017). Therefore, we considered how the physical and social qualities of making and tinkering activities worked together to support (or hinder) caregivers’ engagement. Prior research in museums has highlighted the connection between the physical design and the social affordances of museum experiences. In particular, physical design

features that allow for social interactions (e.g., being able to observe or work together with others) promote greater engagement among visitors in general (Allen, 2004; Dancstep & Sindorf, 2018a,b; Humphrey & Gutwill, 2005), and families in particular (Borun et al., 1997).

Creators of maker spaces consider similar factors when designing their environments. For example, the Making + Learning project (www.makingandlearning.org) provides tools to help the creators of maker spaces make intentional decisions about key features of their spaces, including the types of materials (simple vs complex, digital vs analog), the arrangement of seating and workstations (communal vs individual), the types of activities offered (process-focused vs product-focused), as well as choices about social aspects of the space (such as the amount and type of facilitation). Within maker spaces designed for youth and adults, tools are chosen strategically to maximize opportunities for learners to transform them (Keune & Peppler, 2018), and materials are made visible and reachable to support design practices (Litts, 2015).

Making and tinkering activities in museums and science centers are designed to be accessible to visitors of all ages, and can involve a wide range of materials, facilitation strategies, social contexts, and physical environments. This study systematically examined a range of activities with different combinations of affordances in order to understand what qualities invited caregivers in and shaped their engagement.

Methods

We used a qualitative approach to document the context where making and tinkering activities were taking place (including the physical tools/materials and the social interactions among visitors and staff), and their combined impact on caregivers' engagement (including their

overall participation, the roles they played during the activity, and their responses to the experience).

Setting

Data were gathered between October 2017 and June 2018. During this time, the museum offered a range of making and tinkering activities, which varied in their physical location, materials, and facilitation. All activities were offered as drop-in experiences, so that families could choose to participate at any point during their visits. Activities varied from week to week, allowing us to examine what qualities of different activities contributed to caregivers' engagement. A list of activities included in the final dataset is provided in Table 1.

Museum context. Over half of the observations were gathered during after-school hours that were marketed to families from the museum's local community. During these weekday afternoon hours, the museum was generally not crowded, and the majority of visitors in the museum were local families participating in after-school programming. Admission to the museum was free to families during these times. Both making and tinkering activities were available, with a goal of providing opportunities for children to explore a variety of tools and materials during their visits. During these times, visitors at the museum were primarily Hispanic or Latino families who were either bilingual or Spanish-speaking. The remainder of the data was gathered during weekends, school holidays, and hours when the museum offered free admission. The museum was generally busier at these times, and the majority of visitors were from the greater New York City area or nearby neighborhoods in Queens, with a smaller number of families visiting from other regions. On average during these times, 31% of museum visitors were white, 22% Hispanic or Latino, 18% Asian, 11% African American, 1% Native American,

and 9% identifying with multiple ethnicities, and 9% preferring not to report their ethnicities. Across the entire sample, family groups tended to include 1-2 caregivers visiting with 1-2 children (Average = 1.7 children per group).

Making and Tinkering Activities

We intentionally included a wide variety of making and tinkering activities in this study. In the research within the Maker movement, the line between “making” and “tinkering” is often blurred, but in the current study, tinkering activities focused on open-ended exploration and playful experimentation with materials (following Resnick & Rosenbaum, 2013), while making activities focused on using tools or technologies to create a finished product (Halverson & Sheridan, 2014; Martin, 2015). The two types of activities were developed with distinct goals and facilitation strategies in mind (described below). The diversity in the activities we observed allowed us to determine what characteristics of the physical design, materials, or facilitation made a difference in inviting families in or supporting caregivers’ engagement.

Tinkering activities were designed to be lightly facilitated and to focus on open-ended exploration and experimentation with simple or repurposed materials. For example, visitors created simple circuits with circuit blocks, made ball runs from cardboard and recycled materials, or built ziplines from string, paperclips, and rubber bands. They generally involved only everyday, familiar tools (e.g., scissors). They took place in one of two spaces: the museum’s science library, an enclosed and quiet space separated from most museum exhibits, with round tables that seated four to six people; and at pop-up tables in a multipurpose/interstitial space near the museum’s cafeteria, where families gathered for other after-school programming.

Maker activities (woodworking, virtual reality drawing, fashion design, etc) were designed to focus on skill-building — each activity showed visitors how to use a specific tool or technology to complete a simple design project. These activities took place in either the museum's Maker Space or Design Lab. The museum's Maker Space is an enclosed space with one entrance, with a variety of tools and projects on display, and modular tables and seating. Design Lab is a large 9,000 square foot space divided into multiple sections, each with open sight-lines to other museum exhibits. Because maker activities often involved learning about new tools, facilitators typically gave some instructions as visitors entered, and checked in with them as needed to offer help and suggestions. Depending on the types of tools involved, the amount and timing of this facilitation varied.

Procedure

Data included observations and semi-structured interviews with caregivers participating in the activities described above, as well as discussions with Maker Space staff. Data collection involved: 1) Written field notes documenting the overall participation of family groups (defined as including at least one child age 4 or older and at least one adult caregiver visiting the museum together). Field notes documented the physical location of activities, the tools and materials used, facilitation strategies employed by Maker Space staff, the general context within the museum (e.g., crowdedness, time of day), and how visitors approached and participated in the activities, including whether caregivers were present while children participated. Debriefing discussions with Maker Space staff and facilitators after each day of data collection were also documented with written notes, and these data were added to field notes.

2) Observations and exit interviews with a sample of caregivers who participated in each activity. The researcher used a combination of purposive and random sampling, observing family groups with at least one child over age 4 participating in the activity with at least one adult caregiver. The final sample included observations of 88 family groups and exit interviews with a subset of 66 caregivers. Children in these family groups ranged in age from 3 to 14, with an average age of 6.88 (SD = 2.56). The remaining 22 caregivers who were observed did not complete an exit interview due to time constraints or language barriers. The total number of observations and interviews for each activity observed, along with children's average age, is provided in Table 1.

The researcher began each observation by selecting the next family to enter the space after the prior observation and interview was complete. The researcher took notes while caregivers and children participated in the activity, recording the time spent and a running record of their participation. As families were exiting, the researcher approached the caregiver(s) in the group, stated that the museum was interested in finding out what parents and caregivers thought about the activity, and asked if they would be willing to take part in an anonymous interview. Interviews took place in relatively quiet areas of the museum where children were able to play nearby. Observations lasted an average of 27 minutes (SD = 19 minutes), and interviews lasted approximately 10 minutes.

Exit interviews with caregivers included questions about families' prior visitation to the museum and to Maker Space, descriptions of the activity and their involvement in their own words, how they felt children benefitted from participating, whether they benefitted themselves (as adults), and whether they did any similar activities together at home or elsewhere (either making or other creative or science-related activities). Interviews were conducted in English (N

= 56) or Spanish (N = 10), with the assistance of bilingual museum staff. The complete interview protocol is provided in the Appendix.

[Place Table 1 approximately here]

Data analysis

Because activities changed from week-to-week and month-to-month, the goal in this study was not to conduct a controlled comparison, but rather to document the qualities of each activity in detail and examine data qualitatively for factors that might explain caregivers' involvement. As such, qualitative analysis was inductive and data-driven. First, we used open coding to identify and describe portions of the field notes, observations, and interview data that related to physical factors (aspects of the environment, tools, and materials), social factors (aspects of facilitation or interactions among family members or with other visitors), and caregivers' participation and engagement (their roles in the activity and perceived benefits for children and themselves). Next, we grouped related concepts together using constant comparison to compare new observations to previously collected data, group related concepts, and define larger themes across the entire dataset (Corbin & Strauss, 2015), and recoded data in iterative rounds of analysis. Finally, we organized themes based on their relationships to each other, examining how physical and social factors interacted with one another and related to caregivers' engagement. Although we used existing research on exhibit design, museum facilitation, and parent-child interaction as sensitizing concepts throughout this process (Bowen, 2006), we defined themes and the connections between them inductively from the data.

During data analysis, validity was established by gathering multiple sources of evidence and placing more weight on themes that appeared across more than one data source, including field notes, observations, discussions with Maker Space staff, and caregivers' own responses in interviews (when available). We also shared preliminary findings with Maker Space staff and advisors for feedback and alternative interpretations, and looked for disconfirming evidence as we identified possible causal connections between factors.

Results

Our analysis examined 1) the role of the physical and social setting on caregivers' engagement in the activities, and 2) caregivers' descriptions of the benefits of these experiences.

How did the physical and social setting shape caregivers' participation?

We examined how certain qualities of the activities influenced whether and how caregivers participated in each of the activities. We observed the role caregivers played, and then verified our observations by asking caregivers to describe what they and their children did in follow-up interviews. The number of observations and interviews for each of the activities observed is provided in Table 1.

Of the 88 families who were observed, 80 demonstrated one predominant role during the majority of the observation time and in their descriptions of their own involvement in the interview, falling into one of the following categories: 34 were primarily involved in facilitating their children's activity, 27 were primarily involved in observing their children, and 19 were primarily involved in making alongside their children. Table 2 shows sample responses for each

of these categories. For the remaining nine caregivers, observations and interviews did not provide sufficient evidence to establish a single predominant role.

[Place Table 2 approximately here]

We found multiple aspects of the physical and social setting influenced how caregivers engaged in the activities. A description of the qualities of the environment that were associated with caregiver engagement is provided in Table 3.

[Place Table 3 approximately here]

Arrangement of space and materials. Two aspects of the physical environment were important in inviting caregivers and families in and opening up space for their participation. First, the *visibility of the activities* affected whether and how caregivers participated, across both the making and tinkering activities. For example, when activities had *open sightlines* to other parts of the museum, such that they were visible from a distance, caregivers were more likely to be involved in facilitating or making, as they were able to watch others participating first before then trying it for themselves or helping their children. On the other hand, when activities were too close to other exhibits or amenities, caregivers occasionally allowed children to participate on their own and chose to observe from nearby instead. For maker activities specifically, when facilitators showed families *examples of finished products* before they began, this also invited caregivers to explore the materials and try the activities for themselves.

Second, the arrangement of tools and materials influenced caregivers' involvement. When activities were set up with *communal seating arrangements* where visitors (and staff) shared the same pool of materials, caregivers were more likely to work side-by-side with children, which supported them in both facilitating and making. This pattern was observed across both the making and tinkering activities. For example, caregivers in virtual reality and fashion design activities were often observed showing children some of the materials and then beginning their own projects once children were engaged. For some other tools, tables were arranged in a circle or U-shape, with visitors and staff sitting on both sides and facing each other. This less formal setup invited more visitors in, resulting in a domino effect that encouraged even more families to enter.

Communal seating arrangements also meant that Maker Space staff participated in the activity alongside families, sharing the same set of materials. Staff projects prompted conversations and questions from visitors, and staff modeled tool use and were available to help without intruding on families' own interactions. For example, in the virtual reality activity, caregivers were able to continue working on their own collages while facilitators sitting at the same table helped their children. With activities such as knitting and 3D pens, staff created small samples while chatting with families, and left their work out on the tables as inspiration.

In contrast, when activities were set up with *single stations* (for example, a small table with one set of woodworking tools), caregivers were more likely to sit next to or opposite children at the table and to be involved as facilitators or observers rather than makers, depending on facilitators' availability and level of involvement. The limited amount of materials communicated that the activity was primarily for children, even when additional stations were available, and staff either worked at separate stations (when available) or stood nearby and

watched from a distance, checking in occasionally with families. Maker Space staff described how caregivers sometimes appeared hesitant or self-conscious when given their own materials to use in these situations. Nevertheless, some caregivers said they appreciated an individual station setup because it gave them dedicated space to work with their children.

Novelty vs. familiarity. Novel tools and materials in some of the maker activities (e.g., virtual reality goggles, 3D pens, scroll saws) motivated caregivers to engage directly in making, with many describing the opportunity to learn how to use a new tool (for their children, themselves, or both) as a key motivator driving their participation as a family. For example, one family described themselves as “crafty” and said they “have done various small sewing projects, crochet, peg dolls,” but were excited by the opportunity to learn needle felting, and the caregiver made her own project in parallel with her children: “it’s not something I’d have done with them, because I don’t know how to do it. So it was new exposure.” Another caregiver working with 3D pens said, “The most interesting thing was learning a new tool. Kind of like a new toy at Christmas.” Another highlighted the importance of new experiences for her children: “Kids’ brains are developing so fast. Having new experiences, trying new things, anything that’s helping them try something and not be afraid to try something new is a good thing.”

In contrast, familiar tools and materials (e.g., fabric, collaging, hand tools) supported caregivers as facilitators of their children’s learning. For example, tinkering activities (e.g., ball runs, ziplines, circuit blocks) used common and repurposed objects such as batteries, light bulbs, paperclips, cardboard, and caregivers frequently helped children think about how to use these materials or provided physical assistance. In interviews, caregivers spoke about supporting children’s learning over time, linking the activities to children’s prior experiences and interests (e.g., “She’d never done circuits before, but she had helped her brother repair a racecar toy”;

“We always do everything together at home, like changing filters on the vacuum, changing batteries in the remote... He loves to see how things work and the mechanisms inside things.”). Maker activities that used more familiar rather than high tech tools (such as woodworking hand tools, or knitting/crochet) prompted similar types of interactions. Even when the materials were familiar, caregivers said they benefitted from the variety of different activities that were available for children to try at the museum (e.g., “I wouldn’t do this at home or have so many options for different things to do.”).

Direction & timing of facilitation. We found two aspects of facilitation made a difference in shaping caregivers’ involvement across both the making and tinkering activities. First, allowing everyone in the group to *immediately engage with the tools and materials* was effective in supporting caregivers’ participation as facilitators and as makers. In these instances, staff would provide a brief demonstration, invite families to explore the materials, and then step back, allowing caregivers to participate in any way they chose. This type of light-touch facilitation (often referred to as *fading*) was observed across many observations in both the making and tinkering activities. For example, facilitators introduced virtual reality by showing visitors a finished virtual drawing, and offered paper collaging supplies, which required little explanation or help, allowing caregivers to be involved right away. Only after family members finished this part of the activity did facilitators explain how to use the virtual reality goggles. Likewise, Maker Space staff introduced many tools (from woodworking hand tools to 3D pens) by giving visitors materials to work with and allowing them to explore what the tool could do.

The immediate engagement seemed to lower barriers for caregivers to be involved, allowing adults to explore the materials openly, which often led to them creating their own projects and reflecting on the process of making. For example, one caregiver worked on a virtual

reality drawing in parallel with her daughter, and remarked: “It felt like I was just putting things randomly, but it works... it surprises you that it actually comes out well. You don’t have to be an artist.” Another using 3D pens described it as, “something you can make for yourself, starting from nothing and just drawing, and you end up with a thing.” A caregiver working on fashion design with her son said, “We’re each making our own outfit. ... I like that you can create as you go, come up with your own idea piece by piece, and do what you want.” For these individuals, the immediate accessibility of materials and minimal instructions led to the perception that they were “allowed to play,” occasionally referencing the permission they felt they were granted and the benefits for their own wellbeing (e.g., “To have a moment to create — We spend so much time working, doing what you *need* to do rather than what you *want* to do.”).

The second aspect of facilitation that influenced caregivers’ participation was whether they directed their assistance towards children or caregivers. As described above, facilitators often observed families from nearby and stepped in as needed to answer questions and offer help. When facilitators directed this assistance *toward caregivers*, this supported caregivers as facilitators, helping them help their children. For example, with the circuit block activity, facilitators tended to explain the basic idea to caregivers but then remained on the sidelines until families had a question. In contrast, when facilitators gave introductions or one-on-one help directly *to children*, caregivers were more likely to defer to the facilitator and observe. Some caregivers preferred this style of facilitation, however (e.g., one caregiver said she appreciated observing while her child had a “private tutorial” and others appreciated that children were being “supervised” by experienced staff). In addition, this style of facilitating occasionally allowed caregivers to work on their own projects as makers — for example, if facilitators stepped in to help children when they observed caregivers deeply involved in their own work.

These results suggest that while caregivers may sometimes allow facilitators to take the lead in showing children what to do, lighter facilitation that invited everyone in the group to use the materials, and that was directed towards caregivers (or caregivers and children together) was effective in promoting caregivers' own engagement in the activities. In addition, this style of facilitating was more responsive to families' strengths and prior knowledge, as facilitators spent more time observing how families were interacting before offering their assistance, and allowed caregivers to decide how best to help their children.

How did caregivers describe the benefits of the activities for their children and themselves?

As illustrated by the examples in Table 2, caregivers described a variety of benefits for children and for themselves, and their responses varied based on the role that they played. For example, the majority of caregivers who were primarily involved in observing their children emphasized the independence that children gained (e.g., "It was fun watching her, seeing how she can do it herself"), or their own desire to watch how children approached the experience (e.g., "To see what she thinks and how she thinks about things."). In this way, "observing" was not necessarily a passive role, as caregivers were often actively noticing and reflecting on what children were doing. Even so, other caregivers said they appreciated being able to relax while children were occupied in productive ways (e.g., "We enjoy [coming here] at the end of the school week... I can come here and decompress. ...They're using their brains and engaged on their own.") especially when facilitators were available (e.g., "[The staff] keep an eye out for safety but respect what kids want to do and give them the space to try things." And "It's good for my kids to talk to someone else outside of their family, because of homeschooling.").

The majority of the caregivers who took on a facilitating role focused on the benefits of spending time with their children, and also sought out information and techniques that would help them be better facilitators — for example, gathering information about activities they could do at home with their children (e.g., “[I get] new ideas for stuff to do with my kids. Virtual reality is a great thing for me to learn about, especially if we can do it again at home”) and watching how museum staff assisted children in learning new concepts or mastering new tools (e.g., one parent remarked about a circuit activity, “Now I know that you can teach kids about this kind of stuff, because I wouldn’t have known how to do that.”). As such, they described themselves benefitting as adult learners in the sense that they learned new ideas and techniques that they could apply elsewhere with their children.

While many caregivers across all roles focused on the overall novelty of the experience for their children (e.g., “[I liked] watching him use tools he’s never used before” and “it’s great to expose them to this. It broadens their bank of knowledge.”), caregivers who were involved as makers specifically pointed out the value of children creating something themselves (e.g., One parent said, after watching her child practice using a scroll saw, “He started out making lines and now he’s made his whole name. That’s what he’s gotten out of it, the confidence to know how to do that.”). Caregivers who facilitated described both the overall novelty and the opportunity for children to create/make.

Caregivers who engaged in making also reported many benefits for themselves as adult learners — including building their creativity (e.g., “I got to know that I’m still creative. That I can still do it”), being “allowed to play,” and having a break from their day-to-day obligations in order to do something rewarding for themselves (e.g., “Tapping into my inner child and creating stuff. I’m not often able to do that because I’m always working a lot.”). These caregivers focused

on the experiential process of making and its benefits, and stated that they and their children benefitted in complementary ways from making together.

Our data highlight three key findings: 1) Caregivers were involved in their children's making and tinkering in a variety of ways, including helping their children, observing, and participating as makers themselves; 2) The design and facilitation of the activities influenced whether and how caregivers were involved, and 3) Caregivers across all roles described themselves as learners, but responded to different aspects of the experience — learning about their children, about how to support their children's learning, or developing their own skills and interests.

Discussion

In this study, we examined how caregivers participated in drop-in making and tinkering activities during family visits to museums, and the factors that related to their engagement as facilitators of children's learning and as learners themselves. This study focused on an understudied aspect of family learning in maker spaces: the physical and social qualities of maker experiences in museums that invite families' participation and that support caregivers' engagement within a single visit. We also examined caregivers' interpretation of their own experiences as learners in these settings.

Overall, we found that facilitation played a prominent role in shaping the ways that caregivers participated in these activities. The making and tinkering activities observed in this study were designed such that the overall amount of facilitation was lower in the tinkering programs, which were more exploratory and self-directed. However, what we observed was that the type of facilitation mattered more than the amount in shifting how caregivers were involved.

Therefore, we saw relatively few overall differences between the making and tinkering activities, and instead observed facilitation strategies that seemed to invite caregivers to participate in more active ways, without being intrusive or prescriptive. Facilitators accomplished this in multiple ways — by providing information directly to caregivers rather than speaking only to children, by allowing everyone in the group to immediately engage with the materials, and by modeling the activity nearby. These findings mirror previous studies demonstrating that facilitators can have a profound impact in supporting and influencing caregivers' involvement in family-focused museum experiences (Brahms & Crowley, 2016; Pattison et al, 2012). Our study extends this line of work by highlighting a range of strategies that facilitators can use to negotiate these interactions and provide enough information for families to begin without undermining caregivers' agency or imposing on families' interactions with one another.

The physical setting and materials also influenced the roles that caregivers took on. Aspects of the physical setting that encouraged social interactions, such as communal seating arrangements and the ability to view other visitors, were especially important in encouraging caregivers to be involved in facilitating or making. Previous studies have found that exhibits that allow for social interactions generally increase visitor engagement (Humphrey & Gutwill, 2005), and are more inclusive across gender lines (Dancstep & Sindorf, 2018). Our findings suggest that maker activities can also be designed to use direct and peripheral social interaction to appeal to caregivers in family groups.

The novelty of the tools provided also encouraged also caregivers to engage in making. This was one feature that differentiated the making versus tinkering activities, as maker activities in this study were more likely to include novel tools that caregivers were interested in learning about on their own, whereas tinkering activities involved relatively familiar materials,

positioning caregivers as facilitators rather than co-learners. Other studies have examined the benefits of providing opportunities for caregivers to build familiarity with novel tools (such as computational tools) on their own as well as with their children, and has found that these independent experiences as adult learners can help caregivers build confidence in helping and collaborating with their children (Roque, 2016; Roque et al., 2016). In the current study, we found that caregivers who were engaged as makers also described their own learning in terms of the creative process and the benefits of making something by hand. This suggests that maker experiences can build caregivers' familiarity not only with the tools themselves but also with the potential value of making as a way of learning.

Different goals and priorities were also evident in our observations: Not all caregivers were engaged in facilitating their children's learning or being "makers" themselves. A large percentage of caregivers preferred to observe rather than be actively involved, and some families split up so that children could participate on their own. Caregivers who took on less active roles nonetheless noticed many aspects of children's learning (e.g., how children were building confidence by accomplishing something on their own). Other times caregivers' goals were quite personal (e.g., relishing the opportunity to watch how their children approached a new experience). At times, caregivers' desire to allow children to explore independently meant that caregivers were minimally involved, an outcome that did not necessarily align with the museum's expectations for family-focused museum experiences. Prior research on parent-child interactions in museums has discussed the tensions that can arise between families' goals for their visits and the implicit agendas of museums and maker spaces (e.g., Gaskins, 2008; Pattison & Dierking, 2012; Wood & Wolf, 2010). Our results not only add to the field's understanding about how families interpret their shared experiences in maker spaces, but also articulate what

“engagement” looked like for caregivers who were primarily standing back and observing. These findings highlight the multiplicity of learning goals that are possible for both caregivers and children within family maker experiences, whether caregivers choose to watch or actively participate.

There are a number of limitations of this study that warrant further investigation. Our findings are based on observations and interviews with a sample of family groups who visited the museum, and those who were able to complete an exit interview after participating in a making or tinkering activity. Therefore, this study did not include the perspectives of caregivers who chose not to attend the museum to begin with, or who were not willing or able to speak with a researcher. While much of the data collection was done on weekdays when the museum offered free admission to families, financial barriers may have prevented some families from attending during weekend or holiday hours. In addition, our study was necessarily limited to one museum in one region of the United States, and interviews were conducted only in English or Spanish. Recognizing that caregiver-child interactions and ways of learning are culturally situated (Gaskins, 2008; Bang et al, 2015), a larger study including visitors from different regions and a wider range of cultures would add to the field’s understanding of how the design of maker programs can be tailored to support caregivers in different communities. Further, the caregivers who participated in this study had children ranging in age from age 4 to 14, and many family groups contained siblings of different ages, which may have influenced caregivers’ needs, motivations, and expectations for their visits. Future studies might delve more deeply into how children’s ages and the composition of family groups affect the roles caregivers play during their visits. Despite these limitations, this study demonstrated the impact of physical and social factors

on family audiences, offering strategies that can be tested and refined in a wider range of settings.

Conclusion

Together, these results highlight the complex interplay between physical and social qualities of museum-based making and tinkering activities, and their combined impact on caregivers' engagement during family visits. The findings suggest strategies that museums can use to welcome family audiences to learn together through making, and to recognize and support the variety of roles that caregivers can play in these experiences. More generally, this study points to the need to consider educational goals for adults as well as children when developing and implementing maker activities for families. In some instances, museums may wish to encourage a particular role for caregivers — for example, prompting caregivers to observe in order to support children's independence and self-confidence, asking caregivers to work together with their children on a collaborative project, or encouraging caregivers to engage in making for themselves as a way of exercising their own creativity or gaining insight into the process of making. Each of these educational goals has distinct design and facilitation implications (e.g., choosing to direct assistance toward caregivers versus children, choosing novel versus familiar materials, choosing individual versus communal work stations, etc).

Further, by being aware of the variety of ways that caregivers approach and respond to drop-in making and tinkering activities, museums and maker spaces can be strategic in using complementary and inclusive strategies to support all family groups. In particular, light-touch facilitation practices that acknowledge the adults in the group and invite immediate exploration by visitors of all ages can create space for a wider range of family interactions. By striving to

engage caregivers in multiple different ways, these strategies may lead to greater participation and deeper engagement in learning through making for multigenerational groups.

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Table 1. Making and tinkering activities observed

Name	Total Observed	Total Interviewed	Average child's age (std. dev)	Description
Tinkering (total)	35	22	6.52 (2.41)	Visitors experimented with different materials each week, exploring circuit blocks, ziplines, ball runs, mazes, etc.
Making (total, includes activities listed below)	53	44	6.97 (2.55)	Visitors used a variety of tools and materials to create their own design projects. (see below for breakdown by activity)
Woodworking	13	13	7.85 (2.17)	Visitors used tools such as hand tools, scroll saws, and mini-lathes, to create something to take home (e.g., a puzzle).
Virtual Reality	18	11	7.24 (2.98)	Visitors created a drawing or collage on gridded paper and then viewed it as a 3D panorama using VR goggles.
Fashion design	12	12	5.86 (2.03)	Visitors created clothing for wooden figures or life-sized dress forms using fabric, ribbon, buttons, tape, and other materials.
Other Tools	10	8	6.92 (3.01)	Visitors practiced using a variety of tools and materials drawn from "50 Tools." Observations included high-tech tools (3D pens and printers) and low-tech tools (knitting and needle felting).

Table 2. Caregivers' participation in making and tinkering activities, and responses in interviews

Role	Observed caregiver behaviors	Caregivers' self-reported benefits for themselves	Caregivers' self-reported benefits for their children	Sample responses
Observing	Allowing children to participate in the activity (independently or with help from facilitators) while watching from nearby	Noticing children's thinking or interests, Taking a break while children do something constructive	Having a new experience, Gaining independence, confidence in figuring something out for themselves	<p>"I like watching their brains work. You can see how they think while you're watching them."</p> <p>"By seeing how she plays, I can see what she's interested in. Because I go to work and don't always have time to see how she reacts to things and how she plays with her friends."</p> <p>"I enjoyed watching them, seeing how they develop, and seeing how they get self-confident."</p> <p>"Kids are productively busy, and it's self-guided, so we can have a break."</p> <p>"I wanted her to make it herself so I tried not to help too much."</p>
Facilitating	Assisting children (either verbally or physically) in using the materials and/or completing a design project together	Bonding, doing something together, Learning new tools/ideas, Getting ideas to try at home, Watching facilitators help children	Having a new experience, Experiencing the process of making/creating, Bonding, doing something together	<p>"The most interesting part was working together, spending time with him and helping him do things."</p> <p>"It was fun to help them and see what they did."</p> <p>"Just trying to introduce different concepts to her – anything that gives her an entry into science or gets her thinking in a different way."</p> <p>"[Watching museum staff] helped me know how to help her with those kinds of tools."</p> <p>"Now I know that you can teach kids about this kind of stuff, because I wouldn't have known how to do that."</p>
Making	Using the tools and materials themselves and/or completing their own design project, in parallel with children	Process of making as play and relaxation, Learning new tools/ideas, Using imagination and creativity	Experiencing the process of making/creating, Using imagination and creativity	<p>"That as an adult, that I'm allowed to do it along with them. It was fun to be able to make [something] myself because usually this stuff is just for them."</p> <p>"Tapping into my inner child and creating stuff. I'm not often able to do that because I'm always working a lot."</p> <p>"To have a moment to create. We spend so much time working, doing what we need to do rather than what you want to do."</p> <p>"We had never done felting before. It was interesting because it's not something I'd have done with them, because I don't know how to do it."</p>

Table 3. Summary of factors shaping caregivers' engagement

	Observing	Facilitating	Making
Arrangement of space and materials	Directly adjacent to other exhibits and amenities	Open sightlines, visible from a distance	Open sightlines, visible from a distance; seeing examples of finished products
	Individual stations; Seating along periphery	Individual stations or communal seating with shared pools of materials	Communal seating with shared pools of materials
Novelty & familiarity	Either familiar or novel materials	Familiar materials	Novel tools and materials
Facilitation direction & timing	Facilitation directed at children	Facilitation directed at adults	Facilitation directed at both adults and children
	Longer initial instructions from facilitators	Allowing immediate engagement with materials	Allowing immediate engagement with materials

Appendix

Interview protocol

1. Have you ever been to the museum before? Have you ever been to this part of the museum before?
2. What brought you to the museum today? What made you decide to come?
3. Tell me about what you were doing just now: What were your children doing? What were you doing?
4. Does this program relate to anything you've done with your children before (at home or elsewhere)?
5. What was the most interesting part about doing this (for you, and for your children)? What was the most challenging part?
6. What do you hope your children get out of doing this? What's good for them about doing it?
7. Do you get anything out of this too, speaking for yourself? What's good about doing this for you as a caregiver or as an adult at the museum?

Biographical Notes

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